Preliminary Data Gap Analysis

Pebble Project Environmental Impact Statement

Resource: Geohazards and Spills (Tailings)			
Project Component	**Analysis Component**	**Description**	**Data Recommendations**
Mine Site: TSF, Ponds, Quarries, and LGO Stockpile	Affected Environment/ Effects Analysis: TSF and Pond Embankments; LGO Stockpile; Quarries A, B and C.	Additional information is needed on the available competent materials that can be quarried for embankment construction, and the geotechnical parameters of embankment and stockpile foundation and construction fill materials, to evaluate stability and seepage impacts.	Additional geotechnical data needs related to foundations, fill materials, and quarries: • Provide GIS layer(s) with test pits, geotechnical drillholes, and seismic line locations for Mine Study Area (from EBD Chap.6) to overlay with current mine plan details. • Summarize the geotechnical characterizations and geotechnical parameters of planned embankment fill materials and foundation soil/rock used for stability, deformation, and seepage analyses. • Describe the types of rock that are available and suitable from Quarries A, B and C for tailings and pond embankment construction, along with their durability and suitability. (Note: some of this may be available in EBD Chap.6 appendices, depending on GIS overlay.) • Quantify available materials in the proposed quarries compared to the tailings and pond embankment tonnage needs.
Mine Site: TSF, Ponds, LGO Stockpile	Effects Analysis: Earthquakes, Embankment and Stockpile Stability	Stability analyses (including seismic design event analyses and design input parameters) are necessary to evaluate risk of dam/slope failure and potential related effects on environment.	Provide stability analysis (under static and earthquake conditions) for 4 TSF embankments, LGO stockpile, 2 seepage pond embankments (at main and south TSF), and berms/slopes at 2 water management ponds (at LGO and pit); including operating basis and maximum design earthquakes (OBE and MDE), design ground motion, bedrock foundation assumptions, and factors of safety to support selection of upstream and downstream slopes. Describe USGS and site-specific probabilistic

			and deterministic seismic hazard analyses computations and peak ground acceleration selected for the embankment stability and deformation analyses.
Mine Site: TSF and Ponds	Effects Analysis: Earthquakes, Embankment Stability	Numerical seismic deformation analysis of TSF and pond embankments is necessary to evaluate impacts to embankments during major earthquake, risk of dam failure, and potential related effects on environment.	Provide numerical seismic deformation analysis of TSF and pond embankments to support selection of upstream and downstream slopes, ultimate crest heights, and freeboard above tailings and water surfaces.
Mine Site: TSF and Ponds	Effects Analysis: TSF and Pond Embankment Stability, Seepage Hazards	Seepage analysis and internal zoning details are needed to evaluate seepage controls and safety of structures with appropriate filters to resist internal erosion (piping), dam failure, and related effects on environment.	Provide information on internal filter zones, material types, seepage controls, grout curtain details, and seepage analysis for each TSF embankment, seepage collection pond embankment, and water management pond berm. Demonstrate that internal zoning meets accepted filter criteria to ensure resistance to piping and internal erosion potential, and no losses of tailings and contact water to the environment.
Mine Site: TSF	Effects Analysis: TSF Main Embankment Stability	Additional information is needed on the feasibility and stability of centerline construction for the higher embankment raises.	Describe how the upstream part of the centerline raises would be built on tailings if it is found the tailings cannot support the fill loading. (Note: Centerline raises and no liner is a similar design to the Mt. Polley tailings dam that breached, which could draw comparison scrutiny, as opposed to downstream raises with a liner.)
Mine Site: TSF	Effects Analysis: TSF Internal Embankment, Bulk and Pyritic Tailings Storage Cells	Additional information is needed on the planned bulk and pyrite cell splits of 88% and 12% tailings volume, respectively, to evaluate overall constructability of the TSF.	Location/size of TSF internal embankment is dependent on estimated breakdown of 88% bulk tailings and 12% pyritic tailings coming from process plant. Describe how the 88% and 12% splits were determined and the confidence of achieving the splits. Describe contingency plan(s) to adjust process operations and/or modify the TSF cell configurations if the 88% and 12% splits cannot be achieved. Explain if and how the internal embankment design and construction would be

			impacted or adjusted.
Mine Site: TSF	Effects Analysis: TSF Bulk Tailings Storage Cell water balance and tailings beach	Additional information is needed on confidence that water discharge can be managed sufficiently to maintain tailings beach, to evaluate hydrologic effects on dam safety.	Describe the water balance estimates for the bulk tailings storage cell. Demonstrate that water management and discharge can be adequately achieved continually to allow for the development and continual maintenance of a tailings beach, and the IDF volume and freeboard above the beach.
Mine Site: TSF	Effects Analysis: bulk tailings generation, thickened disposal, and Bulk Tailings Storage Cell	Additional information is required on disposal of bulk tailings by thickening to a 55% solids slurry to support evaluation of hydrologic impacts on dam safety.	Describe steps taken to reach a bulk tailings thickened discharge concept of a 55%-solids slurry, versus a lower % solids aqueous slurry. Provide examples of successful cold-region thickened TSFs. Describe water balance mitigations if 55% thickening cannot be achieved.
Mine Site: TSF	Effects Analysis: TSF Operations, phreatic surface across Bulk Tailings Storage Cell	Additional information is needed on the plan to develop and maintain a phreatic surface towards the main embankment, to evaluate potential hydrologic effects on dam safety.	Describe the bulk tailings and embankment fill permeability characteristics that support the concept of developing and maintaining a phreatic surface towards the main embankment.
Mine Site: TSF	Affected Environment/ Effects Analysis: Climate Data for Embankment Design	Additional information is needed on correlation between Iliamna village and mine site climate conditions to evaluate hydrologic hazards to TSF and dam raise schedule.	Describe mine site weather data correlations with Iliamna weather data (i.e. temperature, snow, rain, evaporation, wind, etc.), and weather data used to select PMF and IDF and support embankment design (freeboard, water management). (Note: Red Dog Mine precipitation was found to be significantly higher than that at Kotzebue and required earlier than planned tailings dam raises.)
Mine Site: Open Pit	Effects Analysis: Earthquakes, Pit Slope Stability	Stability analyses of pit slopes are necessary to evaluate risk of slope failure and potential related effects on workers	Provide stability analysis (under static and earthquake conditions) during both operations (dewatered) and closure periods.

		and surrounding environment.	
Amakdedori Port	Affected Environment/ Effects Analysis: Dredge Stockpile and Port Structures	Additional foundation information is needed to evaluate geohazards/ seismic impacts to port structures.	Provide additional information on subsurface geotechnical conditions for terminal, causeway, and sheetpile cell jetty.*
Amakdedori Port	Effects Analysis: Earthquakes, Stability of Dredge Stockpile and Port Structures	Stability analyses of port structures are necessary to evaluate risk of damage and potential related effects on environment.	Provide stability analyses for dredge stockpile, sediment pond berm, terminal patio, causeway, and sheetpile cell jetty/wharf; under static and earthquake conditions, and at low tide for marine structures.
Transportation Corridor: Iliamna Lake	Affected Environment/ Effects Analysis: Lake Ice Hazards	Additional information needed on Iliamna Lake ice conditions to evaluate potential ice hazard impacts to ferry operations and lake port facilities.	Limited information is available in the literature on Iliamna Lake ice conditions (some data on ice coverage/seasons, very little on thickness and movements/processes). Provide additional data on Iliamna Lake ice thickness, ice movement/ridges, and potential for ice rideup/pileup.* Alternatively, compile data from nearby lakes and/or other cold regions analogs.
Transportation Corridor: Iliamna Lake	Affected Environment/ Effects Analysis: Seiche Hazards	Additional information is needed on the potential for seiche development on Iliamna Lake as a result of a major earthquake; needed to estimate likelihood of damage to ferry and lakeshore facilities.	Limited information is available on seiche development in Iliamna Lake during major earthquakes (Note: boat damage in the Lower 48 has occurred from seiches from large Alaska earthquakes.) Compile additional information on seiche causes and historical analogs to predict possible effects in Iliamna Lake.
Transportation Corridor: Major River Crossings	Affected Environment/ Effects Analysis: Risk of HDD Frac-out	Additional information on rivers that may require HDD crossings for pipeline is needed to assess potential frac-out impacts.	Provide information on which rivers are likely to require HDD for the pipeline crossing, length and depth of crossings, and subsurface conditions.*
Pipeline: Cook Inlet Bluff HDD	Effects Analysis: Bluff/Slope Stabilty	Additional information needed on Pipeline HDD	Provide HDD details (length, depth, angle) and cross-section from HDD work area to emergence on seafloor.

		at East Cook Inlet bluff to evaluate potential bluff/slope stability impacts.	

*Possible mitigation recommendation for final design or monitoring if not available for the EIS.

Data Reviewed

1. Project Description and Figures (PLP permit Application Attachments A & D)
2. EBD Chapters 2, 6, and 30: Climate and Meteorology – Bristol Bay Drainages; and Geotechnical Studies, Seismicity, and Volcanism – Bristol Bay and Cook Inlet Drainages
3. Knight Piesold (2006), Northern Dynasty Mines Inc, Pebble Project, Tailings Impoundment G, Initial Application Report.
4. NOAA (2015) Chart 16640 for Lower Cook Inlet.
5. Internet search for Iliamna Lake ice data (e.g., Verrier and Kirchner 2016; Billmeier 2015; Metzker 1967)
6. Internet search for seiches in Alaska (e.g., Barberopolou et al. 2004; McGarr and Vorhis 1968)
7. Alaska Dam Safety Program Guidelines, Draft Revision July 2017

GIS Layers Needed

1. Test pits, geotech drillholes, and seismic line locations for Mine Study Area (from EBD Chap.6) overlain with mine plan details (from Project Description figures M-001 to M-020)